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PROGRESS REPORT NO. 3
ON
INVESTIGATION OF DETACHABLE ROCK-DRILL BITS

BY

MCHENRY MOSIER

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PROGRESS REPORT NO. 3 ON

INVESTIGATION OF DETACHABLE ROCK-DRILL BITS[1]

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By McHenry Mosier[2]

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INTRODUCTION

This paper constitutes the third progress report on a national survey f the use of detachable bits in metal mines. It presents comparative costs f drilling with conventional and detachable bits and describes the operating ractice in rock drilling and the reconditioning of drill steel and bits at mines not discussed in previous reports.[3]

ACKNOWLEDGMENTS

This report has been prepared with the assistance and cooperation of the fficials and staff members at the mines visited. Costs and other data at dividual mines were developed and furnished by the operators.

SUMMARY AND GENERAL CONCLUSIONS DERIVED FROM DATA DEVELOPED BY 10 MINES

Five of the 10 mines described in this circular have adopted the detach- le bit as standard for all drilling operations. At the mines where compara- ive costs are available the saving in cost per foot of hole drilled with the etachable bit is 10 to 40 percent exclusive of the reduction in the labor ost of operating the rock drill.

Four of the mines use detachable bits for special work. At one of these he particular use is for drilling long holes because the cost of forging arge-gage starters is excessive. At the other three of these mines, all of hich are in the Tri-State district, excessive abrasion in drilling practical- y destroys the bit in one run. This makes the general use of detachable its in their present state of development prohibitive in cost.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6936.

[2] Supervising engineer, metal-mining research section, Mining Division, U. S. Bureau of Mines.

[3] Mosier, McHenry, Progress Report on Investigation of Detachable Rock-Drill Bits: Inf. Circ. 6877, Bureau of Mines, 1936, 9 pp. Progress Report No. 2 on Investigation of Detachable Rock-Drill Bits: Inf. Circ. 6911, Bureau of Mines, 1936, 20 pp.

At one mine where drilling and blasting conditions are especially favo the entire range of bit gages for conventional drill steel is below that fo the current pattern of detachable bits. The advantage is obviously with th small conventional bit at this mine.

Detailed Drilling Data and Costs at Individual Mines

The following detailed data for individual mines include descriptions rock-drill operating practice, drill-sharpening equipment, and methods for reconditioning drill steel, and give comparative summaries of drilling performance and costs for both conventional and detachable bits.

MASCOT MINE
AMERICAN ZINC CO.
MASCOT, TENN.

Conclusions

The operating cost per foot of hole drilled has been reduced 10.7 percent through the adoption of detachable bits. The recent tendency to regr bits oftener has reduced the unit cost of regrinding, improved the drillin speed, and increased the total footage drilled per bit purchased.

Operating Practice

The prevailing formations are dolomite and limestone, which are fairl hard and uniform but when chertified are rather abrasive. The zinc ore, w is sulphide, occurs in veinlet-like forms in brecciated dolomite.

The drifters used in stoping have a 3-inch diameter, while those used in development have a 3-1/2-inch diameter. In stoping, each drill is operated by one man, while in development a helper is furnished for each two machinemen. Air pressure is 90 pounds at the compressor and at least 75 p at the drill. The average depth of holes drilled is 8-1/2 feet.

The conventional bit on the regular drill steel formerly used was the Carr type with end hole. Clearance tapers were 5° and 14°, with 90° betw faces. Starters were 2-1/4-inch gage, with a reduction of 1/8 inch for each 2-foot change. The drill-steel sections were the same as those the present rods for detachable bits. Regular drill-steel distribution a underground transportation were expensive processes because of the large active mine area. The mine workings extend over an area 2 miles long and 1/4 mile wide and have a vertical range of 600 feet.

The drill shop for detachable-bit work is underground on the 520-foo level at No. 2 shaft on the intake side of the mechanically controlled pr ventilation circuit. The equipment consists of the following:

2 bit-grinding machines with 12-inch wheels.
2 bench grinders with 8-inch wheels.

1 machine sharpener.
1 furnace with oil burner using high-pressure air.
1 anvil and various small tools.
1 water quenching-tank.
1 oil quenching-tank with water jacket on sides and bottom.

is underground shop is conveniently arranged, with ample space for equipment d storage of drill steel and bits.

The several sizes and sections of drill steel are enumerated below:

1-1/4 inch lugged hollow round, for drifters.
1-inch hollow round with 7/8-inch hexagon shanks, for jackhammers on block-holing.
7/8-inch solid hexagon, for hand-rotated stopers.

During 1935 bits (including those that had been reforged) were reground average of 7.76 times. This makes a total of 8.76 uses per bit. The ency of current practice is to regrind bits oftener and thus not to low them to become as dull as formerly. This results in (1) a larger ber of regrinds per bit, (2) a smaller cost per regrind, (3) a greater otage drilled per bit, and (4) a higher rate of penetration with (5) rrespondingly increased footage per machine shift. The rate of penetration is just over 7 inches per minute, actual cutting time. An average of inches is drilled per bit dulled. In grinding and gaging, 765 bits re sharpened per wheel used. Approximately 1 percent of the bits are ost or unaccounted for. Bits are discarded at 1-1/2-inch gage unless they an be reforged, which is done if the threads are good and there is at least inch of stock below the cutting edge. The direct labor and supply cost r reforging is 2.6 cents per bit and for hardening 0.9 cent per bit, a tal cost of 3.5 cents per bit. All bits marked for discard by the blackith in the underground shop are checked further on the surface in daylight the machine-drill repairman. After being reforged the bits are heated o 1,400° F. and hardened by quenching in cold water with a submergence of to 3/4 inch, depending on the stock.

The thread end of the rod is forged at an estimated 1,900° to 2,000° . The steel is reheated to 1,400° or 1,500° F. before being subjected to n interrupted quench. It is quenched in oil for about 20 seconds, then ransferred to water and submerged to a depth of 3/8 inch. By forging the hreads in suitable dies in the machine sharpener, breakage has been reduced om 30 to an average of 6 rods per day. This corresponds to a breakage of percent when calculated on the times-used basis.

The heat treatment for the shank end of the rod is the same as for the thread end.

Two men are required in the shop for regrinding bits, reconditioning ro and issuing bits and rods to the miners. In addition they do all the regula underground blacksmith work. Whenever these men report trouble with the bi rods from any particular miner the mine foreman makes an immediate inspectio his working place and equipment. The foreman carries a special test bit fro which a small sector has been removed. This makes it possible to see the en the rod and its contact with the bit after the bit is screwed in place.

Each miner is provided with two bit carriers, one of which is left at the shop each day for exchange. The capacity of the carrier for stope mine is 6 bits and for development miners 10 bits. The miner picks up his carri filled with sharp bits at the drill shop as he goes on shift and returns a his bits in it as he goes off shift. The miner thus loses no time by this arrangement. For this service only one attendant is required at the shop for 15 minutes in the morning and 15 minutes in the afternoon. All drilli is done on day shift. The carrier is a simple sheet-metal box without side and with a thin divider punched to form individual receptacles for the bits It has a hinged cover that can be fastened shut by means of a lug and a cotter key. A rigid handle of 3/8-inch round iron is provided at one end.

Costs

The following tabulation shows the comparative operating costs of dril ing with conventional and detachable bits. The labor cost of operating the machine drill, which is not included in this summary, has been reduced 14 percent through the use of detachable bits.

Cost per foot drilled

	Conventional bits on regular drill steel, 5 years, 1927-31	Detachab 12 mon 193
Drill steel	$0.00541	$0.001
Drill-steel loss	.00027	1/ .000
Detachable bits	—	.005
Shop expense:		
Labor on sharpening	.00509	.005
Grinding and gaging wheels	—	.001
Repairs on sharpener and grinder	.00143	.000
Shop tools	.00023	.000
Fuel oils	.00125	.000
Cyanide and tempering oil	.00008	.000
Transportation of drill steel (underground)	.00255	—
Compressed air for drilling	.06345	.059
Machine drill repairs	.00933	.005
Miscellaneous	.00072	.000
Total operating cost3/	.09281	.08
Total feet drilled	1,738,171	411,7
Feet per machine shift	32.50	37.

1/ Rods only. 2/ The figures in this column were presented at the Chicag meeting of the Western Division of the American Mining Congress in Septem
3/ Does not include drilling labor.

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The capital outlay for the underground-shop equipment for regular drill teel was $2,550. To this was added $750 worth of equipment for detachable its, making a total equipment value of $3,300. To amortize this on a 10-ear basis with interest at 4 percent the annual charge would be 12.33 cents er dollar of the original investment. At the rate of 400,000 feet drilled er year, this is equivalent to $0.0008 per foot of hole for regular drill teel and $0.0010 per foot of hole for detachable bits.

TRI-STATE DISTRICT

Conclusions

Much of the ground is extremely abrasive, so that frequently a bit will ose 3/16 inch or more in gage before the cutting edges become dull. This evere abrasive quality of the ground is reflected further at the crushing and illing plants by the short life of the liner plates in the crushers.

On account of this abrasion a detachable bit seldom can be used more han once. The extreme gage loss reduces the clearance to such an extent hat it would be useless to regrind.

At present, as a matter of economics, the use of detachable bits in his district is limited to special work. At some of the smaller operations he detachable bits have proved advantageous in extremely hard ground. One ine employs these bits in faces difficult of access, as when headings are tarted from points close to the back of high open stopes where the cost of ransporting drill steel is excessive.

BENDELARI MINE,
EAGLE PICHER MINING CO.
TRI-STATE DISTRICT, PICHER, OKLA.

The ground in the tests detailed below is solid, hard, uniform chert or lint, which is exceedingly abrasive. There is also considerable limestone ith crevices or open water courses in which are lime boulders.

The machine drills are 3-1/2 inch drifters, with one miner and one elper per machine. In addition, a few 2-5/8-inch pluggers are used for blockoling. The air pressure at the machine is 80 to 85 pounds. In drifts and tope headings a drifter using regular drill steel will average six 9-foot oles per shift, or a total of 54 feet. In stopes, one drifter with two men ill average 90 to 100 feet per shift in solid ground or 40 feet in open round.

The drill-sharpening shop is at the collar of the service shaft. The quipment consists of:

1 drill sharpener with punch.
1 oil furnace, single side opening.
1 double emery wheel.
1 forge.

1 piston-drill air hammer.
2 benches, vises and various small tools.

An interesting device in this shop is a patented burner of local desig that uses either oil or gas. It is said to consume relatively little fuel. It consists of an 8-inch piece of 1-inch pipe telescoped in a 2-inch pipe o the same length. Through the center of the closed end of these pipes is inserted a 3/8-inch nipple or nozzle for high-pressure air. When air flows through the nozzle fuel oil is drawn up from a storage tank through a 1/2-inch feed line to the jacket that surrounds the 1-inch pipe and then throu 1/4-inch holes in the 1-inch pipe near the closed end, where it is thoroughly mixed with air and atomized before it reaches the combustion end of the burner. At this point a renewable sleeve prevents deterioration of the pi

Conventional Bits on Regular Drill Steel

For drifters 1-1/4-inch hollow lugged round steel is used, and for jackhammers 1-inch hollow collared hexagon, is used. Both of these section contain 0.85 percent carbon. The conventional cross bits have a 90° angle between faces. The single clearance taper is approximately 14°. Gage changes are 1/4 inch on a 24-inch run. Starters or "jumpers" are 3 feet long, with a 2-7/8-inch bit. Finishers are 13 feet long, with a 1-3/4 inch bit. All bits have a center hole.

Bits are forged at an estimated heat of about 1,800° F. On reheating for hardening the temperature is raised to about 1,450° F., and the bits a quenched in water. The same procedure is followed with shanks, except tha quenching is done in oil. Two men spend half their time in the shop and sharpen 70 pieces of steel per day.

To facilitate handling drill steel through the shaft, an iron bucket 8 feet long and 12 inches in diameter is hooked directly to the hoisting cable. On surface and in underground transportation this bucket lies flat on a small truck. Its capacity is 50 pieces of steel. Two of these bucke are hoisted and lowered per day.

Detachable Bits

During a 2-week period in March 1935 two tests were run with detachab bits with a 1.10-percent carbon content and rods with 0.85-percent carbon content for comparison with the record of a year's average of regular dril steel with conventional bits. These bits were used once and discarded on account of their extreme gage loss. The comparative results are shown bel

	Regular drill-steel conventional bits, 1-year average	Detachable	
		Test 1	
Total feet drilled	146,510	710	4,
Average drilling speed, inches per minute	13	13	
Size of drifter, inches	3-1/2	3-1/2	
Inches drilled per bit dulled	84	83	
Breakage of rods, percent of times used	4.4	0	
Loss of steel from all causes, pounds per foot drilled	.14	x	
Feet drilled per machine shift	50.5	44.4	
Tons broken per machine shift	56.9	57.9	

For detachable bits the gage of the 3-foot starters is 2-7/8 inches and 11-foot finishers, 2-1/4 inches.

BARR MINE,
VINEGAR HILL ZINC CO.
TRI-STATE DISTRICT, BAXTER SPRINGS, KANS.

The rock at this mine, which is typical of the Joplin district, is princi- lly a very abrasive solid flint that carries considerable calcium carbonate tiff. It is difficult to drill when fractured on account of the raveling ound that must be spooned after each change. Each 3-1/2-inch drill is erated by a driller and helper.

Drill steel is 1-1/8-inch hollow lugged round. Air pressure at machines 90 pounds. The footage for a machine shift is shown below:

Location	Depth of hole, feet	Total, feet
Stopes	13	65
Stope headings .	10	80
Pull drifts	7	98

The shop for sharpening regular steel is at the collar of the Barr isting shaft. In this shop are three especially constructed trucks for ndling steel. These have four smooth, steel-tread, roller-bearing wheels inches in diameter. Ball-bearing stirrups support a 50- by 120-inch deck, ich stands 39 inches above the cement floor at one end and 42 inches above at the opposite end. This holds the steel at the elevation of the furnace arth. The equipment consists of:

1 sharpening machine.
1 gas-fired, forging furnace (air pressure 8 to 10 lb., gas pressure 8 to 10 oz.).
1 gas-fired tempering furnace.
1 shank grinder.
1 double-wheel bench grinder.
1 forge.
1 anvil.
2 bench vises.
1 power hacksaw.
1 drill press.
1 3- by 4-foot cast-steel floor block or welding table.
1 air hammer.
1 bolt machine.
1 power punch.
1 electric welding outfit.
1 acetylene cutting and welding outfit.

To facilitate the movement of steel in and out of the mine a bucket 12 inches in diameter and 9 feet in length operates from the surface to the mi level through a 16-inch churn-drill hole.

The cross bits have 90° between faces and double clearance tapers of 5 and 14°. The gage change is 1/8 inch on a 24-inch run. All steel is end h The forging temperature is about 1,800° F. Bits are reheated to 1,450° F., determined by a magnetic indicator, and quenched in water. Shanks are heat for at least 9 inches from the end so as to overlap the forging heat and ar quenched in oil. Two men sharpen and one man hardens approximately 200 pie of steel per day.

In the underground station at the churn-drill hole the steel is sorted in lengths and transported to the stopes on small trucks attached to the regular ore trains. One nipper spends part of his time on the underground distribution and collection of steel, at which he is assisted by the miners helpers.

The following data on preliminary tests run in February 1933 were furnished by the staff at the Barr mine:

	Conventional bits, regular drill steel	Detachable bits
Total feet drilled	390	975
Size of machine drill, inches	3 1/2	3 1/2
Inches drilled per bit dulled	24	48
Breakage of rods, percent	1/ 2.8	None
Gage of bits, inches	2-5/8 to 2-1/8	2-1/2 to 2-1/
Gage of loss, average inches per run	5/16	1/4 to 5/16
Tons of ore broken per machine	1/ 76	x
Tons of ore broken per bit used ...	5.9	9.3

1/ Average for 6-month period.

RIALTO MINE,
RIALTO MINING CORP.
TRI-STATE DISTRICT, PICHER, OKLA.

The formations encountered in the test drilling described below are (1) ore in cherty limestone or flint and (2) some open ground in limestone. The flint is extremely abrasive.

The machine drills in use are 3-1/2- and 4-inch drifters with 1-1/4-in lugged hollow round steel. Each machine has a runner and helper. The aver drilling time is about 5 hours per shift. Air pressure is 100 pounds at th compressor and about 90 pounds at the drill.

The central shop, which handles conventional bits on regular steel fo the three mines of this company, is at the collar of the Rialto mill shaft. Its equipment consists of the following:

1 machine sharpener.
1 oil-fired furnace using air at 9 pounds pressure.
1 water quenching-tank.
1 oil quenching-tank.
1 forge.
1 anvil and various small tools.

r transporting steel through the shaft, an iron bucket or carrier 16 inches diameter and 9 feet in length is hooked directly to hoisting cable.

Conventional cross bits are used with a 90° angle between cutting faces double clearance tapers of 5° and 14°. All steel is end-hole. Gage anges are 1/4 inch on a 2-foot run. A 3-inch bit is used for starters or pers; a 2-inch bit for 10-foot drills; and a 1-5/8-inch bit for 17-foot nishers. The estimated forging temperature is 1,900° F. For hardening, s are reheated to 1,450° F. and quenched in water. Shanks likewise are heated to 1,450° F. but are quenched in oil.

One sharpener and his helper sharpen and harden 200 pieces of steel per y in addition to attending to other duties. One nipper is employed under-ound.

Detachable bits are used only for drilling under the difficult conditions at arise when work is started at a point near the back of a high open stope. r this operation a 50-foot drill column was constructed from 4-inch double-rength pipe by welding 3-inch pipe inserts at the joints. A double-screw ck was placed at the foot. A wooden drilling platform was supported on the lumn near the back by means of an extra drill arm, two braces from which were ied to a clamp about 10 feet below. This platform was 43 feet above the oor of the stope. It was served by a wooden extension ladder placed against e wall of the stope.

Regular drill-steel starters are 2-3/4 inches in diameter and are followed three detachable bits with 1/4-inch-gage changes on a 2-foot run. Owing to e high gage loss, there is no regrinding, and bits are discarded after one e.

The mine staff furnished the following data on preliminary tests conducted 1935:

	Conventional bits regular drill steel	Detachable bits
est A. Formation, Solid flint:		
Total feet drilled	112	573
Inches drilled per bit dulled	42	116
est B. Formation, Solid flint and mestone:		
Total feet drilled	72,800	6,400
Breakage of rods, percent	2-1/2	0
Feet drilled per rod	x	[1] 2,133+

[1] No rods broken.

A MINE IN SOUTHEASTERN MISSOURI

Conclusions

Although drilling is not a major problem at this mine, yet it has been given a great deal of attention. The outstanding feature of the drilling practice is the use of small steel, small-diameter bits, and small gage chan In fact, the starters have a smaller gage than the finishers in most distric The use of this small gage, which is possible on account of the nature of th ground and its low abrasive action on the bits, has increased the drilling speed. To compensate for the reduction in area of the hole drilled with smaller gage bits it was necessary to employ an explosive of higher strengt Accordingly, 60 percent gelatin dynamite in 1- by 8-inch sticks was substituted for the 40-percent gelatin dynamite in 1-1/8- by 8-inch sticks form ly used. These changes have effected an appreciable economy in mining.

Detachable bits have not been tried, principally because they cannot be dupplicated in the small gages now in service with regular drill steel.

Operating Practice

The prevailing formation is a dense, dolomitic limestone with occasiona small, soft, shale seams. The ore has a low abrasive index because of its high lime and low silica content. The lime equivalent averages 95 percent while the silica is less than 3 percent.

Jackhammers, which are used on most of the work, have cylinders with either a 2-1/4-inch or 2-3/8-inch bore. Air pressure at the drill is 80 pounds. There is one operator per machine. Drilling speed averages 12 inch per minute, actual cutting time. For a 6-month period in 1935 the average footage per machine shift in stopes and drifts was 99.7 feet. The driller, in addition to drilling and block-holing, transports drill steel, bars down, loads, and blasts. He also clears enough floor area in the stope to enable him to set up his drill. The average depth of hole is 9 feet.

The sharpening shop is underground in an open chamber near the supply shaft. Equipment consists of the following:

- 1 machine sharpener.
- 1 oil-fired furnace.
- 1 shank grinder.
- 1 double emery wheel.
- 1 water quenching-tank.
- 1 oil treatment-tank with pyrometer.

The 7/8-inch hollow hexagonal collared steel with 0.72 percent carbon content has a 19/64-inch hole. Bits on starters are six-point and on the re maining drills four-point, all with a 90° angle between cutting-edge faces and a double taper of 5° and 20°. A 2-foot starter has a 1-3/8-inch gage. a 1/16-inch-gage change and a 2-foot run a 12-foot finisher has a 1-1/16-inc gage. End-hole bits are universal.

Forging temperature is estimated at 1,800° F. Bits are reheated to bout 1,470° F. and quenched in water until black, then immersed for 15 inutes in an oil bath in which the temperature is maintained at 450° F. hanks are given a similar heat treatment except that they are quenched irectly in oil, which is cooled by circulation of water.

About 60 pieces of steel are sharpened per day by a sharpener who pends only a portion of his time on this work.

A unique feature in long-hole prospect drilling is the use of a double hisel bit on 7/8-inch hollow hexagonal steel. Starting at 1-7/8 inches, here is a 1/8-inch gage change on a 2-foot run to 12 feet. From this length o the 22-foot finisher a "following gage" with a differential of approximately 1/64 inch is used.

Drilling Data

Some general drilling data on conventional bits, based on the record of he entire mine for 6 months in 1935, are shown below:

Average drilling speed of jackhammers, actual cutting time, inches per minute	12
Inches drilled per bit dulled	823
Breakage of rods and shanks:	
(a) Percent of times used	0.6
(b) Feet of hole per rod or shank broken	11,340
Loss of drill steel from drilling, breakage, sharpening, reshanking, discards, or unaccounted for, pounds per foot drilled	0.007
Feet drilled per machine shift	99.7
Number of men per machine	1
Effective drilling time, hours per 8-hour shift (includes setting up machine drill and changing steel)	3
Machine drill repair cost per machine shift	$0.04
Cubic feet compressed air per foot of hole (This is total compressed air for all purposes, including blowing for ventilation, leaks, and condensation losses.)	552

BURRA BURRA MINE
TENNESSEE COPPER CO.
COPPER HILL, TENN.

Conclusions

The use of detachable bits is limited to drilling long holes that have a maximum depth of 90 feet. The gage of the starters for these holes is 2-3/4 inches. The comparatively high cost of forging such large bits made it advantageous to adopt detachable bits for this special work.

The formations prevailing at this mine are dense, metamorphosed sedim of varying hardness. Occasionally these rocks exhibit some shattering. Al formations are rather abrasive.

The machine drills in use are 3-1/2- and 4-inch drifters with 1-1/4-in hollow round lugged steel. Ordinarily there is one operator for each drill, except on long-hole work when an operator and a helper are employed. Air pressure is 110 pounds at the compressor, and 90 pounds at the drill. For stopers, 1-inch hollow hexagon steel is used and for jackhammers 7/8-inch hollow hexagon. The size of the hole through the steel is either 9/32 inch or 11/32 inch. The footage per machine shift with conventional bits is sh below:

Class	Depth of hole in feet	Feet per machine shift
Drifter on development	6	66
Stoper in raises	6	51
Jackhammer in stopes	9	56

On an average, 4 feet are drilled per bit dulled.

The drill-sharpening shop is at the collar of the main hoisting shaft. Steel is trucked to the other two operating shafts. The shop equipment con sists of:

3 sharpening machines with punches.
1 spare machine used occasionally for straightening bent steel.
4 oil-burning furnaces with pyrometers.
1 bench grinder for shanks.
1 forge and anvil.
1 water quenching-tank.
1 oil quenching-tank.

For forging bits and shanks the furnace temperature is 1,950° F. On r heating for hardening it is 1,450° F. for bits and 1,500° F. for shanks. S are heated over a slightly greater length than when they are forged, and ar enched in oil of quality standard for this work. The oil is cooled by means cold water that circulates in coils along one side and across the bottom the tank. One perforated-steel rack gives a 15-inch submergence while other, elevated above the surface of the oil, provides means for draining e oil from the drills.

Conventional bits are four-point with an angle of 90° between faces and th double clearance tapers of 5° and 14°. All bits have an end hole. The ickness of the wing, which varies with the gage, is greater than the usual andard at most mines. The gage change is 1/16-inch per foot or 1/8-inch on 2-foot run.

One of the particularly interesting features of this shop is the method sizing and racking the steel. The drills are sorted in the shop to the arest half foot in length. Sets for miners are then assembled with 1/8-ch gage change and a 2-foot run, commencing with either a 2-foot or a 3-ot starter, depending on the comparative stock of steel in even-foot ngths and in odd-foot lengths. The following table shows lengths and ges:

Gage of bit, in inches

ngth of drill steel in feet	Size of steel, in inches		
	1-1/4	1	7/8
2	← 1-7/8	← 1-9/16	← 1-3/4
3 . . .	1-13/16 →	1-1/2 →	1-11/16 →
4	← 1-3/4	← 1-7/16	← 1-5/8
5 . . .	1-11/16 →	1-3/8 →	1-9/16 →
6	← 1-5/8	← 1-5/16	← 1-1/2
7 . . .	1-9/16 →	1-1/4 →	1-7/16 →
8	← 1-1/2	← x	← 1-3/8
9 . . .	1-7/16 →	x →	1-5/16 →
10	← 1-3/8	← x	← 1-1/4

By this means there is a more flexible and accurate segregation of un-of-mine" lengths.

The following tabulation shows the average number of pieces of steel arpened per day with two machine-sharpener shifts.

Size, inches	Number per day
7/8	194
1	50
1-1/4	202
Total . .	446

This is exclusive of shanking and of making up new steel. For this wor
56 gallons of fuel oil are required per day.

The loss in gage is 1/16 to 1/8 inch per bit dulled. The breakage of rods amounts to 2.6 percent of the "times used". The average life of a piece of drill steel is 320 feet of drilling.

In transporting steel through the shaft the drills stand on end in the cage. Underground they are placed on tramcars and handled by motormen to the stope manways, where they are hoisted and lowered in buckets on slides by means of air hoists operated by the miners. As a safety precaution and for protection against the abuse and breakage of steel no drills are thrown down these slides.

Detachable Bits

On account of the expense of forging a large bit, detachable bits were adopted 2 years ago for drilling long holes. These holes have an average depth of 36 feet and a maximum depth of 90 feet. The 1-1/4-inch sectional steel is in 3- and 6-foot lengths. Starters are 2-3/4 inches, with a gage change of 3/32-inch and a run of 3 feet. The loss in gage per run is 3/6-inch. A 4-inch drifter with independent rotation drills 22.6 feet per shif
The average penetration per bit dulled is 48 inches, the same as for regula
drill steel. Bits are shipped some distance to a commercial shop, where th
are reground for 15 cents each.

LONDON MINE,
THE LONDON GOLD MINES CO.
ALMA, COLO.

Conclusions

Detachable bits were adopted about 3 years ago and are giving very sat
factory results. Although complete cost comparisons with conventional bit
cannot be made because records of former drilling are not available, yet i
is evident that detachable bits have effected a large reduction in the expense of transportation and distribution of drill steel.

Operating Practice

Several rocks that differ widely in drilling characteristics are encou
in the London mine. Quartzite presents fairly consistent drilling conditi
and is distinctly abrasive; limestones are dense and uniform; porphyry is
medium soft but not sticky; vein matter is siliceous and abrasive. In gen
the ground may be classed as "good drilling."

The former conventional bits were four-point, with 90° between cutting faces and with 5° and 14° clearance tapers. All bits were end-hole. They had practically no reaming edges. The drill run was 2 feet. Transportati
and distribution of this steel were rather expensive on account of so many

ransfers and consequent rehandling. It was sent in the adit on empty ore cars o one of the supply raises, where it was hoisted to a stope-tramming level nd either carried to a development face or delivered to the foot of a stope aise and hoisted to the floor on the stope, where it finally was available or the stope miner.

The present drills are of three types: 3-1/2-inch drifters, 3-inch auto-atic rotating stopers, and 2-1/8-inch jackhammers. Air pressure at the com-ressor is 90 pounds but is sometimes as low as 70 pounds at the drill. The ootage drilled per shift with one man per drill is given below:

Location	Depth of holes	Feet drilled per machine shift
Drifts and crosscuts ...	5	75
Raises	5	75
Stopes	3-1/2	50

The footage drilled per bit dulled ranges from 20 inches in the hardest ound to 14 feet in the softest, with an average of 48 inches for the entire ne. The average gage loss is 1/16-inch per bit dulled.

The shops are at the portal of the adit through which all ore and sup-lies are trammed. The bit-grinding equipment is installed in the hoistroom the head of the surface incline and is operated on two shifts by the hoist-n during their spare time. The bit grinder is of a standard make, with two eels each having a diameter of 18 inches and a face of 2 inches. It is run a 5 horsepower motor. All grinding is wet, a water pump and sump being tegral parts of the grinder. Sharpening wheels have a life of 7,500 bits ound and gaging wheels of 19,000 bits. One operator can sharpen and gage bits per hour.

The equipment at the blacksmith shop is as follows:

1 machine sharpener.
1 oil furnace with single opening.
1 piston-drill air hammer.
1 drill press.
1 emery wheel.
1 bench and vise.
1 forge and anvil.
1 water quenching-tank.
1 oil quenching-tank.

the adjoining machine shop a bolt machine and lathe are available for ork on drill rods.

All drilling is wet. The following sections of steel are in use:

1-1/8-inch hollow round lugged for drifters.
1-inch hollow quarter octagon with plain shanks for stopers.
1-inch hollow round with hexagonal, collared shanks for jackhammers.

Detachable bits are a threaded type with 4 points and end hole. The angle between cutting edges is 90°, and clearance tapers are 7° and 15°. There is 1/8-inch gage change on a 20-inch run. In 5-foot holes the gages used are 2, 1-7/8, and 1-3/4 inches. All new bits purchased are 2-inch ga Regrinds average 2.25 times per bit, or a total of 3.25 uses per bit purch No hardening is done. About 170 bits are reground per day, and 130 new bi are drawn from the warehouse, making a total of 300 bits used per day. The average penetration per bit dulled is 48 inches. All new and reground bits are issued to the tool nippers by a warehouse attendant. These bits, in sets of three or four, are strung on a loop of wire. The nippers take the to the underground toolhouses, where the miners receive and return them. loss of bits averages 0.65 percent. The threads on the bits are oiled by machine runner so that it is not difficult to remove the bits from the rod A Stillson wrench is sometimes used on the rod with a special bit wrench. The latter has a 30-inch handle made from 1-inch solid round steel, at one end of which is a belled sleeve 2 inches square to fit over the bit, the sleeve being at right angles to the handle.

In fabricating rods the thread end is heated to a white heat and the end slightly upset and made round for a length of 1-1/2 inches. It is the reheated and completely upset in the machine sharpener, after which it is annealed in lime. The machinist then cuts and squares the shoulder and t down the stem in a lathe. The threads are cut on a bolt machine. One man can turn and thread five rods per hour. Upon reheating to cherry-red the threads are quenched in oil until cool. Broken and worn threads average 0.5 percent of the times used.

The shank end on the 1-1/8-inch round steel is upset and lugged on th machine sharpener. The quenching heat overlaps the forging heat. On the quarter octagon steel the shanks are squared by grinding on an emery wheel The hole is countersunk by boring. The end is heated cherry-red for a dis of 5 inches. All shanks are quenched in oil until cool. Broken, battered plugged shanks average 1 percent of the times used. Each development mine provided with two sets of rods, and an extra supply is stored on the suppl raise stations. Each stope miner is furnished one set of rods, with extra available at the foot of stope raises. Nippers handle the rods to and fro these storage places.

The following operating cost of drilling is based on one recent typic month. The average daily footage drilled is 1,200 feet.

Operating Costs for Drilling

	Unit cost	Cost per bit dulled	Cost per foot drilled
1. New bits	$0.234	$0.0720	$0.0180
2. Sorting and issuing bits	--	.0032	.0008
3. Regrinding bits, total	.0234	(.0162)	(.0040)
(a) Labor	1/ .0200	.0138	.0034
(b) Sharpening wheels	.0024	.0017	.0004
(c) Gaging wheels	.0010	.0007	.0002
4. Loss of rods (steel)	--	.0052	.0013
5. Fabricating new rods, labor	--	.0017	.0004
6. Reconditioning rods, labor	--	.0037	.0009
7. General shop expense: Compressed air, electric power, fuel, repairs to equipment, tools, dies, tempering oil, operating supplies	--	.0028	.0007
8. Distribution and collection or rods	--	.0078	.0020
Subtotal, bit and rod cost	--	.1126	.0281
9. Operating rock drills, total	--	(.6776)	(.1694)
(a) Drill miner	--	.4648	.1162
(b) Compressed air	--	.1476	.0369
(c) Machine-drill repairs	--	.0052	.0013
(d) Mine pipelines	--	.0600	.0150
Total operating (exclusive of supervision)	--	.7902	.1975

/ From hoistmen's actual time spent on sharpening work.

CLIMAX MINE,
CLIMAX MOLYBDENUM CO.
CLIMAX, COLO.

Conclusions

Detachable bits are in use at the Climax mine because the cost per foot f hole drilled is less than with the former conventional bit. The principal dvantages of detachable bits over conventional bits are the reduction in ipping (steel-transportation and distribution) costs and the greater footage rilled per machine shift.

Rock Drilled

Much of the drilling is in (1) granite of various degrees of silicification and (2) schist. The ore is rather hard and coarse-breaking. Drilling is considered difficult owing to the tendency of much of the ground to ravel.

Operating Practice

Following an 18-month test period, detachable bits were adopted as st ard for all drilling in July 1934.

Three types of rock drills are in use: 3-1/2- and 4-inch drifters wi 1-1/4 inch hollow, lugged, round steel; 3-inch self-rotating stopers with 1-inch quarter-octagon hollow steel and plain shanks; and 2-1/4-inch jack-hammers with 1-inch collared hollow hexagon steel. There is one operator per machine. Air pressure is 100 pounds at the compressor and about 90 pounds at the drill. The average number of feet drilled per machine shif is 75. The drilling speed (actual cutting time) is 4-1/2 to 30 inches pe minute, with an average of 18 inches per minute. The average gage loss o a 2-foot run is 1/8-inch. Rod breakage is 1.5 percent of the times used in the proportion of three shanks to two thread ends.

With the former regular drill steel three sections were used, depend ing on the length of hole to be drilled and the character of ground. The are listed below, together with the size of starter for the length of hol to be drilled:

Section	Depth of hole, feet	Gage of starter, inches
1-1/4-inch hollow round, lugged	20	2-7/8
	11	2-7/8
	7	2-7/8
1-inch hollow quarter octagon .	8	2-1/8
1-inch hollow hexagon	8	2

The gage change was 1/8-inch on a 2-foot run. The bit was the four- type or conventional cross bit with 90° between cutting faces and with do clearance tapers of 5° and 14°. The forging temperature was 1,750° to 1, F., as estimated in an oil-fired open-flame furnace or as indicated by th pyrometer in an electric furnace.

About 400 bits were sharpened per machine shift. The power consump of the electric furnace, including both forging and quenching heats, was kw-hr. per bit sharpened.

In transporting regular drill steel, one nipper was required for ea three machines in addition to a motorman on the supply train for each ha level. The miners also helped the nippers carry the drill steel into the working faces.

The present drill-steel shop, which is on the surface at the portal the main haulage level, has the following equipment:

1 electric furnace with pyrometer (capacity, 30 2-7/8-inch bits per hour, or 50 2-inch bits per hour).
2 oil-burning furnaces, single side opening, using high-pressure ai
2 machine sharpeners.
1 forge.

1 portable emery wheel.
1 electrically-driven counter-sinking tool.
1 water quenching-tank (3' x 8' x 2').
1 oil quenching-tank (made from steel oil drum).

Stationary racks support the drill steel in front of all furnaces at the level of the hearth. This shop is operated on day shift only with a crew of two men. The bit-sharpening shop, situated underground in the compressor station, has two grinding machines of standard manufacture with wheels of 12-inch diameter and 1-7/8-inch face. Wooden bins are provided for sorting sharp bits into lots with a 1/16-inch gage differential.

Sharp bits are issued to the miners underground at the compressor room by the compressor attendant. The bits are strung on a wire loop in sets of to 10 for large-section steel and 3 to 6 for small-section steel. By selecting bits from alternate bins the gage change is approximately 1/8-inch. Owing to the open market for detachable bits in this district the miners are charged with all "unaccounted-for" bits, unless the shortage is certified by the shift boss as being unavoidable. The loss of bits not thus chargeable to the miners amounts to 0.25 percent.

On the detachable cross bits the cutting edges are ground normal to the axis of the bit with no crowning at the center. The angle between the cutting faces is 90°. Wet grinding is done in the underground shop with soluble cutting oil. The life of sharpening and gaging wheels is respectively 600 and 1,000 bits. The wheels are removed when worn to 7-inch diameter, but many of them are used later at the blacksmith shop. All bits are tested with a file after being sharpened. If too much of the hard structure has not been removed by grinding they are sorted into bins according to their gages. Soft bits are sent outside to the blacksmith shop for hardening. An average of 1,400 bits is used per day; of these, 350 are new and 1,050 resharpened. The grinding wheels are run three shifts per day. In addition to the compressor attendant, who sharpens bits during spare time, there is one operator per shift. An operator first squares up a bit and then sharpens it at the rate of 200 bits per shift for 1-inch rods or 175 bits per shift for 1-1/4-inch rods.

In rehardening the bits at the surface shop they are heated either in an open oil-burning furnace to an estimated 1,450° F. or in the electric furnace equipped with a pyrometer. They are quenched in a tub of still water, in which they are submerged to an approximate depth of 3/16 inch. One man can harden 150 bits per hour by handling two bits at a time with tongs. All rehardened bits are file-tested before being sent into the mine. This test is not only for the degree of hardness but also for the external distance hardened below the cutting faces.

The smallest gage of bits purchased for 1-1/4-inch round steel is 2-3/8 inches, and for 1-inch quarter octagon or 1-inch hexagon it is 2 inches. Bits are ground until sharp rather than to a predetermined gage. After an average of three times used they are rehardened and used three time more, a total of five regrinds or six times used.

In preparing the thread end of the rods the shoulders are forged by u- setting in the machine sharpener. The rods are then annealed in lime and sent to a machine shop in Leadville, where the thread is cut and the should turned in a lathe. The rods are returned to the mine surface shop, where t thread end is heated through a distance of 6 inches and cooled in air to remove forging strains. The tip end of the thread is then reheated for 1/2 inch and quenched in oil. After a file test the thread end is tempered at an estimated temperature of 350° to 400° F., the length of time required depending on the hardness. If the thread is cut too deep or the hardening extends too far from the end of the rod little drilling can be done before breakage results.

The shanks are forged at 1,900° F. and annealed in lime. They are reheated to 1,450° F. and quenched in oil.

Costs

The following cost comparisons were obtained from the 18-month test, w an average of 64 machines in operation.

Conventional bits on regular drill steel

	Cost per bit dulle	
Steel: Total	—	$0.06
Consumption in rock drilling and shop forging	$0.047	—
Lost	.009	—
All other replacement and repairs	.008	—
Shop: Total	—	.04
Sharpening labor	.017	—
Electric power and compressed air	.012	—
Fuel	.011	—
Machine sharpener and forge upkeep	.006	—
Transportation (Nipping): Total	—	.09
Between supply train stations and working faces, including proportionate share of miners' time	.068	—
Supply train, labor	.009	—
" " , power	.004	—
Hoisting, labor	.009	—
" , power	.005	—
Total	--	.2

Detachable bits

	Cost per bit dulled	
el: Total	---	$0.060
New bits	$0.048	---
Steel consumption including lost rods	.012	---
p: Total	---	.058
Grinding bits (total $0.038):		
Labor	.021	---
Wheels	.014	---
Repairs to grinder	.003	---
Power	?	---
Hardening bits	.005	---
Sorting and testing bits	.007	---
Fabricating rods	.006	---
Repairing and straightening rods	.002	---
Fuel	?	---
nsportation (Nipping): Total	---	.006
Rods	.004	---
Checking bits in and out of shop	.002	---
al (exclusive of power for grinding and fuel or shop)	---	.124

An approximation of the bit and rod cost per foot of hole drilled can be e by using the estimated average footage drilled per bit dulled, which is 3 feet for both detachable bits and conventional bits. This estimated com- ative cost per foot is thus $0.043 for conventional bits and $0.026 for de- chable bits. The redution in the cost of drilling through the use of de- chable bits is 40 percent.

UTAH APEX MINE,
UTAH APEX MINING CO.
BINGHAM CANYON, UTAH

Conclusions

A material saving in drilling expense has resulted through the adoption etachable bits, as indicated from the partial costs available. The largest ing lies in the reduction in cost of "nipping" or transportation of steel.

Rock Drilled

he rocks drilled are principally limestone, quartzite, porphyry, and lphide ore. Considerable kaolin is encountered in the stopes, making some- at sticky drilling.

Operating Practice

With conventional bits the average for the mine was 24.9 inches drill per bit dulled, and the cutting speed was 2.15 inches per minute. The usu bit gages were 2-1/8, 2, and 1-7/8 inches.

Equipment formerly used for sharpening conventional bits in the shop on surface at the collar of the shaft comprised:

2 machine sharpeners.
2 oil furnaces with pyrometers.
1 heat-treatment machine.
1 high-pressure pump for unplugging steel.
1 pedestal grinder with two wheels.
2 quenching-tanks.
1 blower with electric motor for low-pressure air.

Drill steel was handled on special trucks over tracks and turntables half of the shop and over a floor of steel plates (turn sheets) in the ot half. The drill steel had a 2-foot run with 1/8-inch gage change. The e hole bits had an angle of 90° between cutting-edge faces, with 5° and 1 clearance tapers. For ease in rotation the bits were forged with partial reaming edges only. About 500 bits per day were sharpened when eight men were in the shop.

In transporting and distributing these drills, the special shop truc were used to carry them to the shaft collar, where they were placed in a bucket 20 inches in diameter and 36 inches long and lashed to the cage f lowering into the mine.

At the several shaft stations they were transferred to another steel truck or a timber truck and taken by a motorman to central stations, whe they were unloaded into racks. A nipper then took them to the working fa as needed and, if necessary, hoisted them with an air hoist to intermedia levels.

Detachable bits are in use at present for all drilling throughout th mine, except that with hand-rotated stopers. Three-inch drifters and 2- inch jackhammers are in general use. Air pressure is 90 pounds at the co pressor and 80 to 85 pounds at the drill. Each machine drill is operate one man, whose effective drilling time after performing other duties is proximately 3 hours. The average number of inches drilled per bit dulle is 61-1/2 at a cutting speed of 2.51 inches per minute with bit gages fr 2-1/8 to 1-3/4 inches.

The shops are now on the surface at the portal of the main tunnel o the 1,000-foot level. In the blacksmith shop is the following equipment

1 machine sharpener.
1 oil forge using high-pressure air.
2 quenching-tanks.

the machine shop is a bit-grinding machine of standard make, using 12-inch els with faces of 1-1/2 and 1-3/4 inches. There is also a lathe with cial dies for threading rods. Storage bins, where reground bits are sorted the nearest 1/8-inch size, are in the adjoining warehouse.

The steel for all types of drills is 1-inch lugged hollow round, ex- t the 1-1/4-inch round steel reserved for sinking shafts and driving ex- ely hard drifts. All this steel, which was purchased several years ago, a sand-cored hole of 5/16-inch diameter. The detachable bits have a 90° le between cutting-edge faces and double taper of 2° and 14°. On a 2-foot the gage change is approximately 1/8-inch. Both end-hole and side-hole s are used, depending on the ground to be drilled.

New bits purchased have an average of 3.88 regrinds or 4.88 uses. Bits not ground to a definite gage but are sharpened and then sorted to the rest 1/8-inch gage. On the average, 35 bits are sharpened per day by the ressor attendant during spare time. Sharpening wheels have a life of 800 s and gaging wheels of 1,200 bits. Bits have not been rehardened at this e.

In fabricating or reconditioning rods the shanks are heated to an esti- ed temperature of 2,000° F. for forging. They are reheated to 1,450° F. uenched in oil until cool. The thread end, like the shank, is given a ging heat of 2,000° F., but it is annealed in lime. After the shoulder urned on the lathe and the threads are cut with the special dies, the ead end is heated to 1,400° or 1,500° F. for 45 minutes and quenched in ntil cold. Approximately six rods per man per shift can be completely ricated on both shank and thread ends.

The miners carry the bits on wire loops. The miners receive the de- hable bits at the warehouse at the beginning of the shift and return there at the end of the shift. Rods are delivered to the working faces the motorman. Each driller has one set of rods at the face with extras conveniently located racks. The average number of bits lost during the 2 years is 3.6 percent. This is rather high because some equipment lost in caving ground. Bits broken averaged 0.93 percent. New bits ed in this 2-year period totaled 6,000, and the number of bits re- ened was 23,583, indicating 29,583 bits used. The shank breakage was percent and thread-end breakage 0.31 percent, making a total rod kage of 0.55 percent of the number of "runs". The steel loss is not n because the rods were fabricated from old drill steel and no records e kept of the number of pieces in service.

The following tabulations show partial costs for both conventional and achable bits:

Conventional bits

	Unit cost	Cost per bit dulled	Cos per f of h
Steel loss: Total	--	$0.037	$0.01
Shop: Total	--	.070	.0
Labor	$0.05	--	
Repairs on equipment, fuel and supplies	.02	--	
Transportation (nipping): Labor	--	1/.120	.0
Total	--	2/.227	2/ .1

Detachable bits

Steel: New bits	.274	.056	.01
Shop:			
Bit grinding, total	.038	.028	.00
Labor	3/.024	--	-
Repairs on equipment and supplies	.014	--	
Reconditioning rods:			
Total labor	.530	.003	.00
Labor on shank end	.183	--	-
Labor on thread end	.347	--	-
Total	--	2/.087	2/.01

1/ Exclusive of motorman and hoistman.

2/ These partial costs are comparable for the two classes of drilling, ex
that with detachable bits no figures are available for the loss of s

3/ Labor charged is for proportionate time of compressor attendant.

IDAHO-MARYLAND MINES,
IDAHO-MARYLAND MINES CORPORATION,
GRASS VALLEY, CALIF.

Conclusions

A saving of over 33 percent in cost of drilling is indicated in the c
per-foot figures as a result of adopting detachable bits. As the operatin
shafts are now approaching their maximum capacity, there are additional in
tangible savings that arise from the elimination of handling drill steel a
from the corresponding increase in effective ore-hoisting time.

Rock Drilled

The rocks drilled, which are principally vein quartz, schist, serpentine, iabase, and diorite, are usually fairly abrasive and medium hard. There is uch shearing, so that drilling conditions are far from uniform.

Operating Practice

Detachable bits are used for all drilling. Most of the drilling is per-ormed with 3-1/4- and 3-1/2-inch drifters and 3-inch automatically rotated topers. Occasional holes are drilled with 2-3/8-inch jackhammers. The air ressure at the compressor at one mine is 85 pounds and at another 100 pounds. oles average 4-1/2 feet in depth and 49.4 feet are drilled per machine shift y one man. The average footage per detachable bit dulled is 2.45 feet com-ared with the former 2.14 feet per conventional bit.

The rod-reconditioning shop is at the collar of the Idaho shaft, re-empering equipment is at the New Brunswick shaft, while grinding wheels are n operation at both of these shafts and at the Bullion shaft as well. Seven rinding machines are in service. At the Idaho shop there are the following:

1 machine sharpener with punch in active service.
2 extra machine sharpeners not in use.
1 rock-drill rod-threading machine.
1 oil furnace using high-pressure air.
1 pedestal steel rack at furnace.
1 shank grinder.
1 air hammer.
1 forge and anvil.
2 quenching-tanks.
2 bit-grinding machines.

The steel used is 1-1/4-inch hollow round lugged for drifters and topers and 1-inch hollow hexagon collared for jackhammers. Rods have 0.90 o 0.95 percent carbon content. The hole is 5/16-inch in diameter. All bits re end hole. There are six regrinds or seven uses per bit purchased. Bits re rehardened once. About 945 bits are used daily, 135 of which are new nd the remaining 810 are resharpened. An experienced operator sharpens and ages 200 bits per shift.

New sharpening wheels, which are 12 inches in diameter, are worn to ap-roximately 8 inches in diameter and then transferred to the other side of he machine for use on gaging. The average number of bits sharpened per heel is 630. The average number ground for each new gaging wheel purchased s 1,010, which corresponds to 1 gaging wheel purchased for each 1.6 sharpen-ng wheels. Gaging wheels are run until the diameter is reduced to 6 inches.

All new bits purchased have a gage of 2-3/8 inches. Bits are rehardened hen this gage is reduced to 2-1/8 inches. This work is done in the shops at he New Brunswick shaft, where a home-made electric muffle furnace has a capacity of 80 bits per hour. The temperature, as indicated by a pyrometer is maintained at 1,370° F. The bits are removed from the furnace with tong two at a time, and are quenched with a quarter-inch submergence in a rising current of cold water.

At the Brunswick shop there are four bit-grinding machines. Sharpened bits are sorted into bins with an average gage differential of 1/8 inch. Gage testing is done by means of accurately spaced parallel angle irons secured to the face of the bins.

Bit-carrying racks with a capacity of 35 new bits, as illustrated in figure 1, are provided for the miners, who obtain their sharp bits at the several sharpening shops at the beginning of the shift and return them to these shops at the close of the shift.

In reconditioning rods the bit end is forged at an estimated 1,800° F annealed in sea sand, and threaded in the rock-drill-rod threading machine It is sprinkled with a surface-hardening powder and reheated through a length of 5 inches to 1,475° F. and quenched in oil. The shank end is given the same treatment, except that there is a 2-inch overlap on the quenching heat and no surface-hardening powder is used. One man reconditions all rods. The life of one set of dies in the threading machine is 225 rods.

Costs

The following tabulations show the details of the cost of drilling w detachable bits and with conventional bits. No data are available for "operating rock drills" under the former practice with conventional bits or for repairs to shop equipment. The cost per foot for conventional bit is $0.0607, while the corresponding cost for detachable bits is $0.0399.

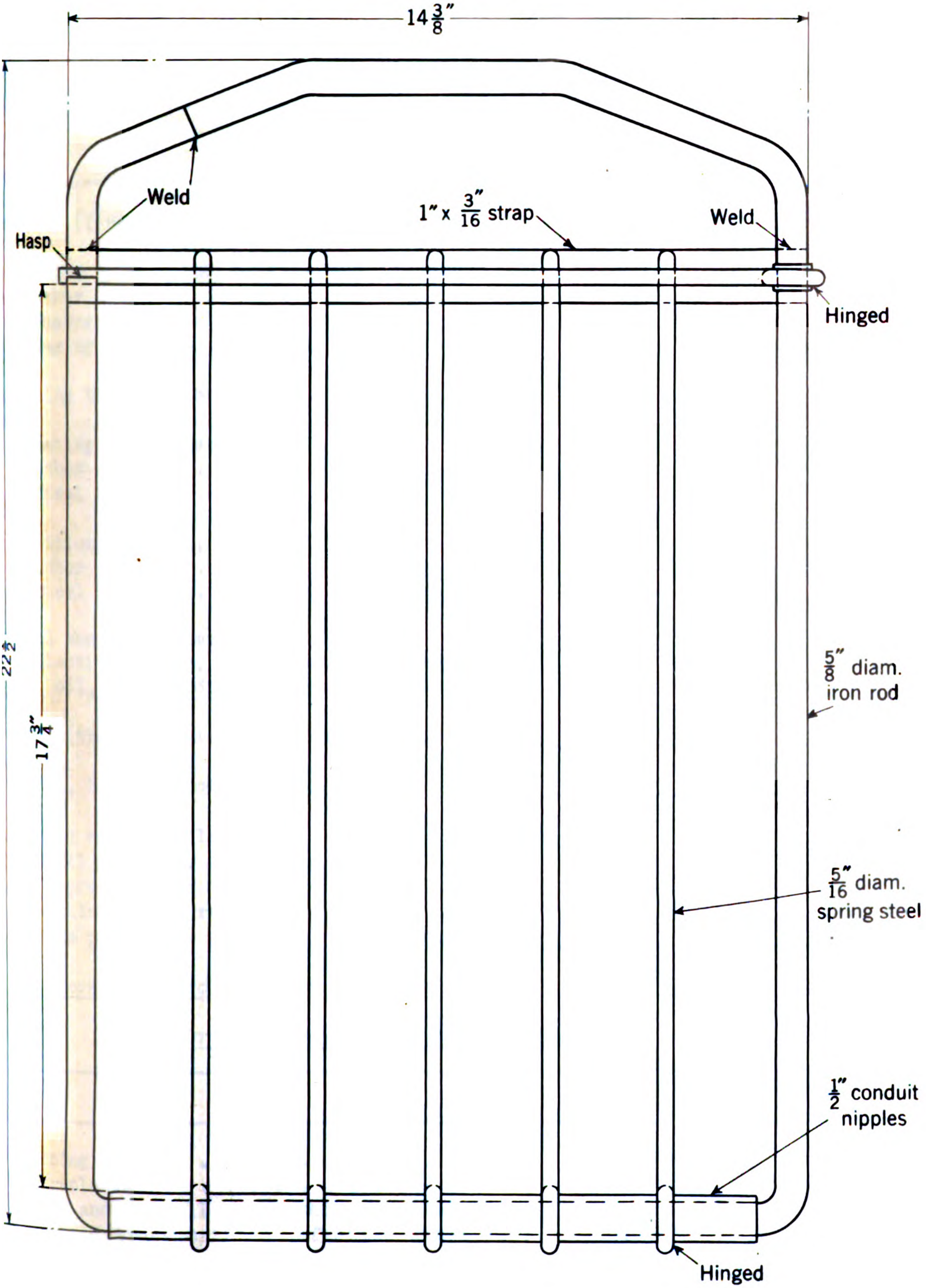

Figure 1.— Bit carrier.

Drilling costs with detachable bits

	Unit cost	Cost per bit dulled	Cost per foot drilled
New bits (7 uses)	$0.31	$0.0445	$0.0182
Regrinding bits (plus sorting and issuing):	.0401	.0344	.0140
Labor	.0250	---	---
Sharpening wheels	.0114	---	---
Gaging wheels	.0037	---	---
Hardening bits, labor	.0133	.0019	.0008
Fabricating new rods:			
Labor	.1250)	.0030	.0012
Steel	3.00)		
Reconditioning rods:			
Labor	.0625)	.0110	.0045
Steel loss	.304)		
General shop expense:			
Electric power, fuel, repairs, tempering oil, tools, dies, miscellaneous supplies	---	---	---
Nipping (transportation of rods estimated) . .	---	.0003	.0001
Subtotal, bit and rod costs	---	.0979	.0399
Operating rock drills:	---	---	.1678
Drill runner	---	---	.1215
Compressed air	---	---	.0163
Machine-drill repairs	---	---	.0108
Mine pipelines	---	---	.0192
Total operating (exclusive of supervision) . .	---	---	.2077

Drilling costs with conventional bits

	Cost per bit sharpened	Cost per foot of hole drilled
Sharpening	$0.0444	---
Steel replacement	.0443	---
Fuel oil and miscellaneous shop supplies . . .	.0050	---
Nipping and transportation of drill steel . .	.0363	---
Total	.1300	1/ 0.0607

1/ No figures available for repairs to shop equipment or operating rock drills.